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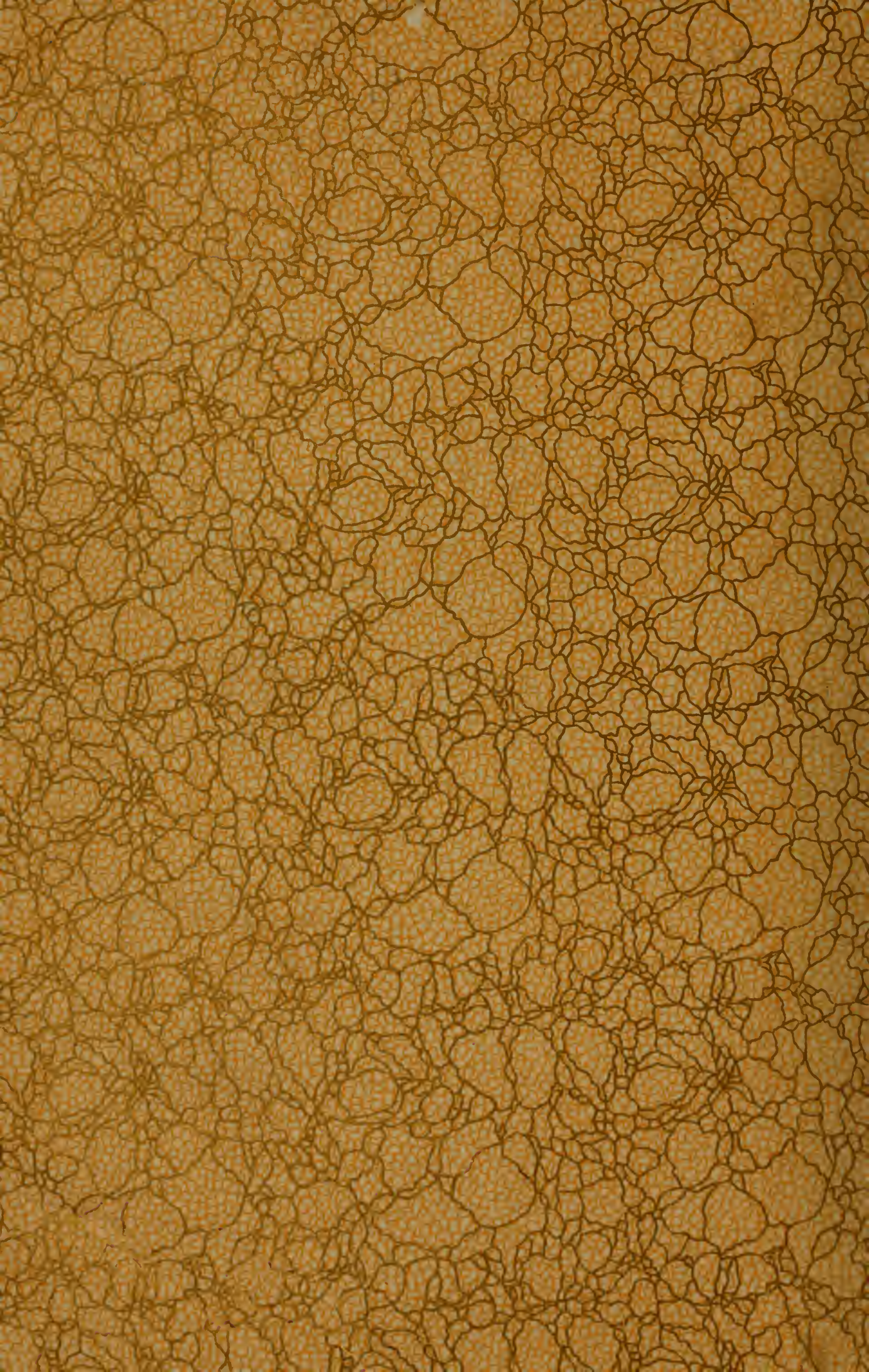
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A DEVICE FOR MEASURING THE TORQUE OF ELECTRICAL INSTRUMENTS

By P. G. Agnew

Different methods have been used to determine the torque of electrical instruments. A common method is to hold the instrument with the axis of the moving element in a horizontal position and place a small weight upon the needle, sliding it along the needle until the desired deflection is obtained when the needle is horizontal. The torque is then the product of the weight and its distance from the pivot.¹ It is not well adapted to such instruments as watthour meters.

A commercial instrument was developed a few years ago especially adapted to measuring the torque of watthour meters.² In this form the force exerted at the end of an arm attached to the moving element is transmitted to the vertical arm of a pivoted right-angled lever, the opposing force being obtained by a small weight on the horizontal arm of the lever.

Recently a somewhat similar device has been described³ in which the force exerted by an arm attached to the moving element is measured by a calibrated coiled spring. In order to change the range, springs of different strength are substituted.

The instrument here described, while specifically designed for the determination of the torque of electrical measuring instruments, is generally applicable to the measurement of small horizontal forces.

¹ This method seems to have been first described by Janus, *Elektrotechnische Zeitschrift*, **26**, p. 560; 1905.

² General Electric Bulletin No. 4331.

³ *Electrical World*, **55**, p. 1212; May 12, 1910.

It operates on the pendulum principle, as is shown in Fig. 1, the essential feature being the use of a scale *S* on a concave spherical surface turned from a brass casting to a radius of curvature of 1 meter. The bob is supported from an adjustable arm and so arranged that the point of support *P* is at the center of curvature

of the spherical scale. A silk fiber is used as suspension and is wound on a friction pin *A*, for convenience in adjusting its length. The fiber passes through a V-shaped notch in the end of a brass strip *B*, which is capable of a small horizontal adjustment to aid in the initial centering. The whole is mounted on an ordinary clamp stand, the tripod being fitted with leveling screws. The clamp *C* allows the scale and bob to be lowered as a unit for convenience in applying to an instrument.

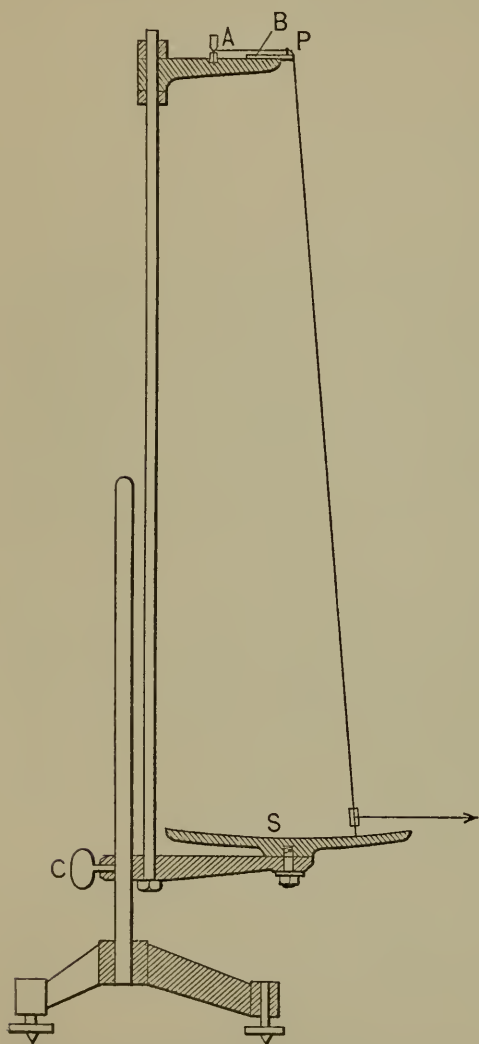


Fig. 1.—Device for Measuring Torque.

The graduations of the scale consist of 153 concentric circles, the distance between successive circles being approximately 1 mm. The diameter of the scale is 30 cm. Since the horizontal deflecting force varies as the tangent of the angle of displacement, it is necessary, in order that the instrument should be direct reading, that the circles should be so spaced as to read off the tangents of the angles of deflection

directly. If the length of the pendulum is 1 meter and the distances between successive circles were exactly 1 mm, we would have for small angles

$$\theta = \tan \theta = .001, .002, .003, \text{ etc.}$$

To make the scale read exact tangents for the larger angles, the following method was adopted.

The hollow spherical bowl, after having been turned by the usual method, was kept in the lathe without being taken from the face plate, the screw carrying the tool post set perpendicular to the axis, and the center then carefully located by the graving tool.⁴ The tool was then moved out from the center, by successive steps, the following distances measured in millimeters

$$\begin{aligned} &1000 \sin (\tan ^{-1} .001) \\ &1000 \sin (\tan ^{-1} .002) \\ &\vdots \\ &\vdots \\ &1000 \sin (\tan ^{-1} .153) \end{aligned}$$

and the 153 circles engraved at these settings. A little consideration will show that this procedure makes the scale read tangents of angles directly, since the radius is 1000 mm. The scale is practically uniform.

The bob consists of a small hollow brass cylinder with a fine sewing needle passed through it perpendicular to the axis, as shown in Fig. 2. The silk fiber by which the horizontal force to be measured is transmitted to the bob is attached to the needle and passes out along the axis of the hollow cylinder. The point of attachment is made at the center of mass of the bob, which, for convenience, is marked by a file scratch. The mass of the bob alone is adjusted to 0.5 gram, but in order to change the range concentric cylinders, each cut in halves, are made to fit snugly over the inner cylinder, as is indicated in Fig. 2. These extra cylinders make the total mass 1, 2, 5, 10, and 20 grams, respectively, giving a range of 40 to 1 for full scale deflection. A radial saw-cut in each half cylinder allows these extra weights to be slipped into place without disconnecting either of the silk fibers.

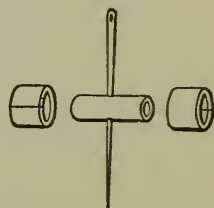


Fig. 2.—Details of Bob.

For the measurement of forces we have the relation

$$\text{Horizontal force} = \text{weight} \times .001 \times \text{reading in divisions.}$$

⁴ The instrument was constructed in the instrument shop of the Bureau of Standards by Mr. Rudolph Hellbach.

In measuring the torque of a deflection instrument—for example, a voltmeter—the horizontal thread is fastened to the pointer at a convenient distance from the pivot, the whole pendulum system adjusted to the proper height, and the voltmeter moved horizontally until the desired deflection is produced. We then have

$$\text{Torque} = \text{arm} \times \text{weight} \times .001 \times \text{reading in divisions.}$$

In the case of a watthour meter it is necessary only to attach the thread to the edge of the disk, apply current and voltage to the meter, and allow the thread to wind upon the disk as far as it will.

The level may be easily checked by lowering the bob until it just clears the scale and swinging it over the different parts of the scale. If it does not touch at any point, the level is correct.

Measurements may easily be made to 0.2 per cent or, if care is used in making the adjustments and the deflection kept near full scale, to 0.1 per cent.

It may be of interest to add a few numerical values to show the order of magnitude of torques ordinarily met with. The following are the least and greatest values found for three different types of instruments, several different makers being represented in each type.

D. C. voltmeters, 0.289 to 2.06 gram-cm; D. C. ammeters, 0.214 to 0.873 gram-cm; A. C. watthour meters, 3.06 to 7.74 gram-cm.

WASHINGTON, June 27, 1910.

